3.—MARINE JURASSIC IN THE NORTH-WEST BASIN, WESTERN AUSTRALIA,

By Curt Teichert.

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CONTENTS.

ABSTRACT.

The discovery of marine strata of Jurassic age in the North-West Basin is announced. They contain *Parachaetetes megalocytus* Pia, *Echinotis sinuata* sp. nov., and *Ostrea tholiformis* Etheridge. The strata are correlated with the marine Bajocian of the Geraldton District, 400 miles to the south of the new locality, and it is concluded that the Bajocian transgression in Western Australia may have had a much wider range than had been supposed. The discovery of Jurassic in the North-West throws important light on the history of the North-West Artesian Basin and may also prove to be of economic interest.

INTRODUCTION.

Jurassic strata were once believed to have a wide distribution in Western Australia. On the latest available geological map of the State (Blatchford 1934) a continuous belt of strata of this age is indicated from Muchea, 30 miles north of Perth, in the south as far as the Fortescue River, about 900 miles up the coast in the north, and again from Wallal, 150 miles north of Port Hedland, to the southern shores of King Sound in the vicinity of Derby. Subsequently it was shown by Raggatt in 1936 that the country indicated as Jurassic in the North-West Basin between the Wooramel River and Onslow actually consisted of strata of Cretaceous age and the Jurassic was altogether eliminated from the map published by this author. Realizing that there was very little or no evidence of Jurassic strata in the greater part of the area formerly believed to be underlain or covered by strata of Jurassic age, Clarke in a recently published sketch map (1938, p. 37) showed the strata of known Jurassic age to be restricted to two areas, viz., a narrow strip of marine and continental deposits in the Geraldton District in the southern part of the State, and a small area of continental deposits in the vicinity of Derby at about lat. 17°. This sketch map is here reproduced, with slight alterations, as fig. 1.

Until recently, the strata of the Geraldton District were the only definitely established marine strata of Jurassic age in Western Australia, and at the same time in Australia in general. Spath (1939) determined the age of these strata as Middle Bajocian. During 1938 and 1939, however, evidence was accumulated proving the existence of strata of approximately the same age in the North-West Basin (see fig. 1).

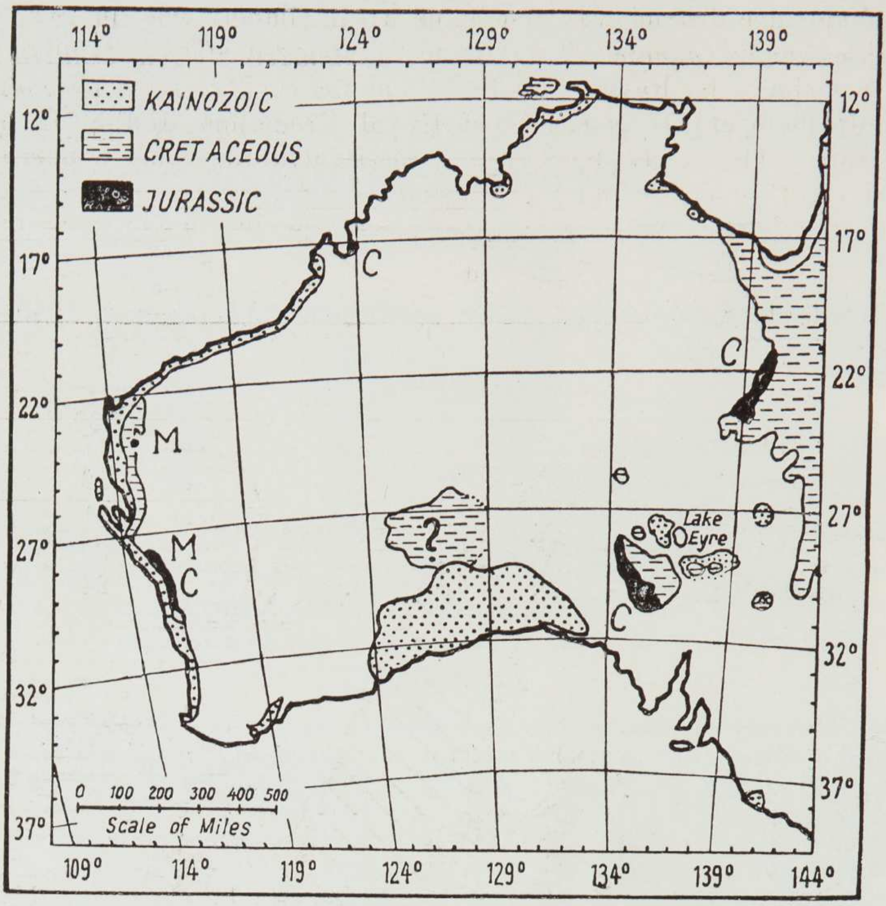


Fig. 1.—Distribution of Mesozoic and Kainozoic rocks in Middle and West Australia.

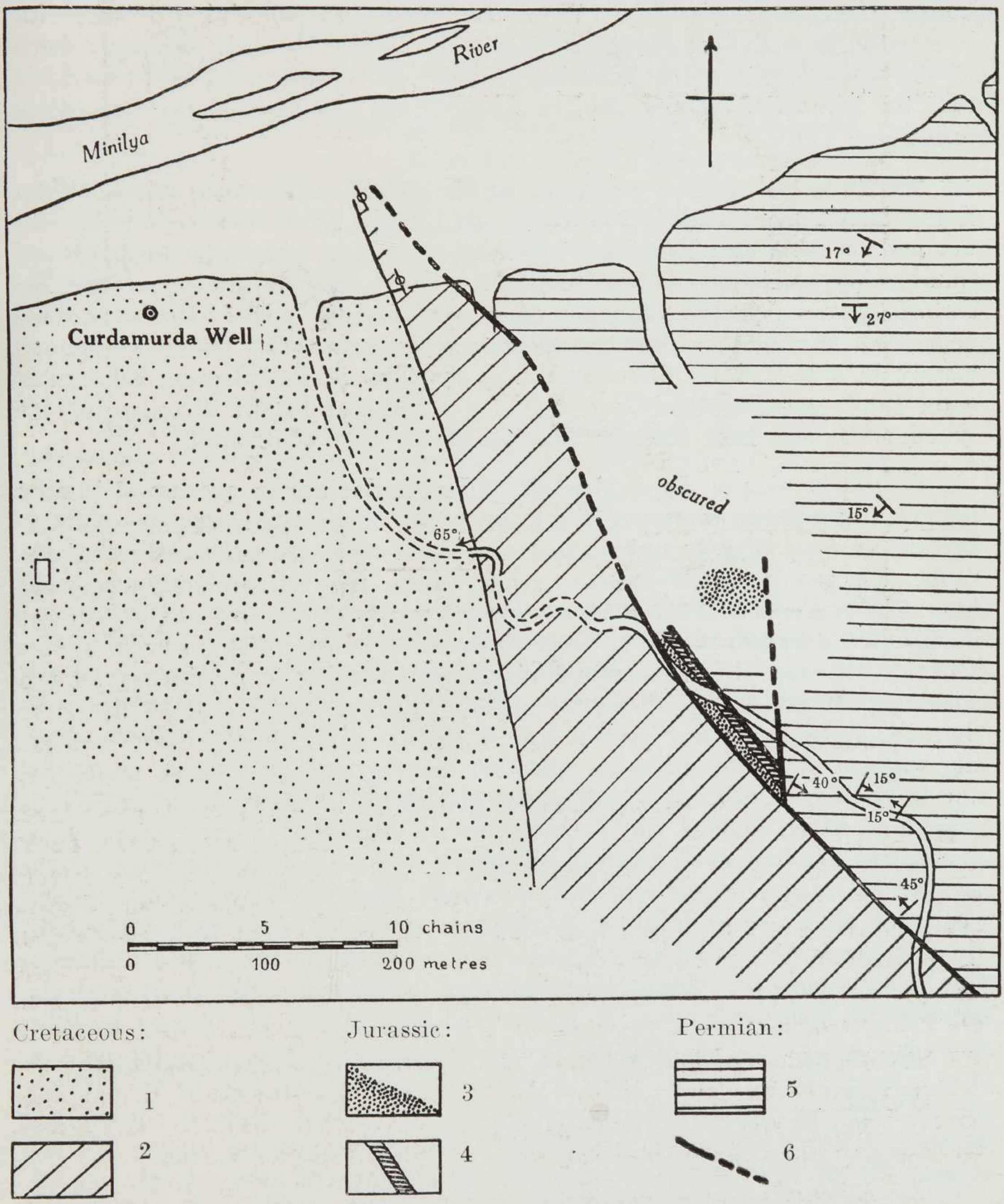
M = marine Bajocian, C = undivided continental Jurassic. The dot at 23°45 lat. marks the situation of map area fig. 2. (Adapted from E. de C. Clarke, 1938.)

The discovery of fossils which later turned out to be of Jurassic age, was first made by Mr. H. Coley at a place about 30 chains (600 meters) southeast of Curdamurda Well on Wandagee Station, near the Minilya River. The writer visited the locality in May, 1938, being then under the impression that the strata in this place were part of the Permian series which is well developed in the immediate vicinity. Up to that time only a few specimens of calcareous algae had been secured from this locality which were sent to Professor Pia in Vienna who immediately stated his opinion (in a letter to the writer) that the algae belonged to a Jurassic genus. In May, 1939, the writer revisited the place on the Minilya River and succeeded in obtaining invertebrate fossils from these algal beds which show definite relationships to fossils of the marine Bajocian series of the Geraldton District.

In the following, a description of the locality and of the invertebrate fossils will be given, whereas the calcareous algae are being described in a separate paper by Professor Pia (1940).

DESCRIPTION OF THE LOCALITY.

The new locality is situated on Wandagee Station, on the south side of the Minilya River, 30 chains (600 metres) southeast of Curdamurda Well. On previous geological maps, up to 1933, the country here was indicated as consisting of "Permo-Carboniferous." The existence of Cretaceous strata in the Wandagee district was first noted by L. Glauert who, in 1926 (p. 53) listed *Dimitobelus canhami* (Tate) from "Wandagee Station, Minilya River," and it was shown by Raggatt, in 1936, that the country formerly mapped as "Permo-Carboniferous" consisted partly of Cretaceous and partly of Permian strata. The newly discovered Jurassic outcrops along a narrow strip between the Cretaceous and the Permian.



1. Siltstone. 2. Greensand. 3. Hard sandstone. 4. Algal sandstone. 5. Wandagee beds. 6. Faults.

Fig. 2.—Geological map of area east and south-east of Curdamuda Well, Wandagee Station, Carnarvon District. (The situation of this area is indicated in fig. 1. For "Curdamurda Well" read "Curdamuda Well.")

Our knowledge of the Cretaceous stratigraphy in this part of Western Australia is entirely due to Raggatt who also proved that along the Minilya River the Cretaceous strata are separated by a major fault from the Permian Wandagee beds lying immediately east of them. In the vicinity of this fault (see fig. 2) the Cretaceous is represented by glauconitic sandstone, partly in vertical position or even slightly overturned, partly with a steep westerly dip, which is overlain by siltstones and cherts. The dip seems to decrease westwards with increasing distance from the fault. Raggatt has shown this series of greensand, siltstones and cherts to be of Lower Cretaceous age and assigned it to the Winning series. No fossils were discovered in the greensand near the Minilya River, but several miles farther south, at Cundy Dam, near Wandagee Woolshed, greensand containing *Dimitobelus* is exposed in a similar stratigraphic position below the siltstones and cherts of the upper part of the Winning series. There can, thus, be little doubt that the greensand of the Minilya River forms the base of the Cretaceous series here (1).

North, as well as just south, of the Minilya River Permian strata (Wandagee beds) are found immediately east of the fault line separating the Cretaceous from the Permian. Usually, they are gypsiferous shales and thin-bedded sandstones, often strongly current-bedded and in places disturbed by minor faults. About a quarter of a mile south of the river these beds form a syncline with dips of both limbs up to 45°, running approximately in a N.E.-S.W. direction. This syncline is abruptly cut off by the main fault, running approximately at right angles to the direction of the syncline. It was here that the Jurassic strata were discovered.

As can be seen on fig. 2, the belt of Lower Cretaceous greensand is very narrow immediately south of the river where the attitude of the strata is vertical or even slightly overturned, and the strike is parallel to that of the fault. The maximum thickness exposed is here 130 feet, probably somewhat less. The greensand belt widens southward, partly owing to a slight decrease in dip of the strata, partly to an increase in thickness. A quarter of a mile south of the river it is 140 metres wide, corresponding to a thickness of the greensand of 410 feet as the strata are dipping west at 65°. Immediately to the east of the greensand there is here a narrow strip, about 13 feet wide on the surface, of unfossiliferous greenish weathering, grey hard sandstone, and to the east of this again a strip, likewise about 13 feet wide, of calcareous sandstone which yielded the Jurassic fossils mentioned above. Both sandstones are exposed over a length of about 470 feet along the edge of the greensand. At their southern end both belts are cut off by a fault striking 170°, and abut against Permian gypsiferous beds and sandstone. The conditions at the north end of the outcrop could not be ascertained, but to the east the Jurassic beds are undoubtedly separated by another strike fault from the gypsiferous Permian rocks.

The following fossils have been obtained from the algal sandstone:

Algae:

Parachaetetes megalocytus Pia.

Lamellibranchiata:

Echinotis sinuata sp. nov.

Ostrea tholiformis Etheridge jr.

(1) The name "Cardabia beds" was given by Glauert in 1926 to the strata with *Dimitobelus* and some of the specimens listed by this author as *Dimitobelus canhami* came undoubtedly from the vicinity of Cundy Dam. Later, Conditt, Rudd, and Raggatt named the entire Lower Cretaceous, including cherts and siltstones above the *Dimitobelus* beds, "Winning series," and Raggatt proposed the name "Cardabia series" for the Upper Cretaceous beds of the North-West Basin (see Raggatt, 1936). The greensand of the Minilya River district thus corresponds to the "Cardabia beds" of Glauert and to the lower part of the "Winning series" of Conditt, Rudd, and Raggatt.

The relationships of the algal beds to the hard sandstone and of both these strata to the Cretaceous greensand could not be established. The following possibilities exist:

(1) Faults separate the hard sandstone from the greensand as well as from the algal beds.

(2) Hard sandstone and algal beds form a conformable series separated from the greensand by a fault.

(3) Algal beds, hard sandstone and greensand are a conformable series.

The age of the unfossiliferous hard sandstone is uncertain, but it is very different in appearance from the Lower Cretaceous greensand or any other known Cretaceous beds here and elsewhere in Western Australia, and therefore probably forms part of the Jurassic sequence. On the other hand, the fault bounding the hard sandstone and algal sandstone belts on the south does not continue into the greensand. It seems, therefore, most reasonable to assume that the hard sandstone and the algal beds form a small fault block which has been squeezed up along the fault between the Cretaceous and the Permian.

Unfortunately, greensand, hard sandstone and algal beds can in this place only be observed in weathered surface outcrops and their true attitude could, therefore, not be determined. It is, however, most likely that they here are steeply dipping to the west and that the entire thickness of the Jurassic, including the hard sandstone, is less than 25 feet.

Slightly north of the north end of the belt of algal limestone is a small area covered with hard sandstone boulders which are similar to the rock of the hard sandstone belt. No surface outcrops are visible and it is thought that this occurrence gives evidence of another small fault block in which the hard sandstone series only is exposed.

CONCLUSIONS.

The marine Jurassic of the North-West Basin as described above, shows relationships to the Middle Bajocian strata of the Geraldton District as suggested by the occurrence of *Echinotis sinuata* and *Ostrea tholiformis* in both areas and it can, therefore, be assumed that the middle Jurassic transgression, so far only known from the country around Geraldton also affected at least part of the North-West Division of Western Australia. Its deposits are probably in most places either buried beneath the Cretaceous sediments or they were subjected to erosion before the Cretaceous sediments were deposited. Further search along the Cretaceous-Permian boundary of the district might, however, reveal additional limited outcrops of Jurassic strata. So far, the one here described is the only outcrop discovered, but the greater part of the North-West has never been examined in detail.

The discovery of Jurassic strata in the Minilya District sheds new light on the history of the North-West Artesian Basin. This Basin, as interpreted by the present writer (1939), is part of the Westralian Geosyncline which here contains 10,000 feet of Permo-Carboniferous and Cretaceo-Tertiary sediments. It is now evident that the time between the Permian and the Cretaceous has not been one of continuous emergence. It may be noted that marine Jurassic is also represented in the northern part of the Westralian Geosyncline, but these strata are of a different age and will be described elsewhere.

With regard to the bearing of the discovery of marine Jurassic in the North-West on economic questions, it may be pointed out that in the country west of the area occupied by the Permo-Carboniferous strata artesian water is obtained from strata below the Cretaceous which are now generally believed to be of Permian age. It must, however, now be regarded as possible that in certain places Jurassic strata may intervene between the Cretaceous and the Permian.

PALAEONTOLOGICAL DESCRIPTIONS.

GENUS **ECHINOTIS** MARWICK.

Genotype: *Avicula echinata* Smith.

The genus (1) was established by Marwick in 1936 for species formerly included in the genus *Pseudomonotis*, but differing from this genus mainly in their long and straight hinge-line. In addition to the genotype a number of mostly Middle Jurassic species will have to be included in this genus, among others *Avicula bramburiensis* Phillips, *Avicula ovalis* Phillips, *Monotis ornati* Quenstedt, *Monotis decussata* Münster, and *Monotis substriata* Münster. The distinguishing features of some of the German Dogger species have recently been discussed by Stoll (1934, p. 18).

Echinotis sinuata sp. nov.

Plate I; Fig. 1-10.

Holotype: No. 19211, Department of Geology, University of Western Australia.

Diagnosis: Outline subcircular, generally smooth primary and secondary ribs, shallow oblique sinus in posterior part of left valve.

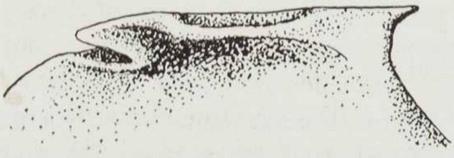


Fig. 3.—Hinge-line of right valve of *Echinotis sinuata* sp. nov. Railway cutting 19½ miles east of Geraldton. No. 19212. Department of Geology, University of Western Australia.

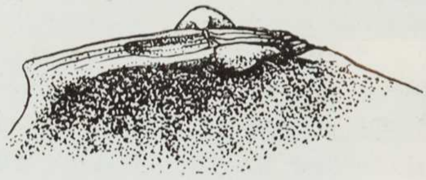


Fig. 4.—Hinge-line of left valve of *Echinotis sinuata* sp. nov. Railway cutting 19½ miles east of Geraldton. No. 19215. Department of Geology, University of Western Australia.

Description: Left valve subcircular, strongly convex, beak slightly projecting over the hinge-line; anterior ear very short, almost obsolete, posterior ear well developed, rectangular; ribbing very faint in the umbonal region, ribs gradually increasing in strength towards the ventral margin; in most specimens separation of ribs into primaries and secondaries well developed at a distance of about one-third the distance from the beak to the ventral margin; growth-lines clearly developed between the ribs, but only in a few specimens visible on the ribs, thus giving the ribs a knotted appearance; there is a slight swelling of the posterior part of the valve, separated from the rest of the valve by a shallow oblique sinus which starts to develop at

(1) Marwick used the spelling *Echinotus* in the heading of his description, but elsewhere throughout the article the spelling *Echinotis* is applied which is here accepted.

distance of about one-fourth the distance between the beak and the postero-ventral margin in adult shells; in different individuals sinus and swelling can be more or less pronounced, in some specimens both are very faint. Hinge (fig. 4) very similar to that of *Echinotis echinata* (see Pompeckj 1901, Marwick 1936); the triangular ligament pit is very shallow. The muscle scar is elliptical and situated slightly behind the centre of the valve. The largest ventral valve in the collection is 25 mm. long and 21 mm. high. (pl. 1, fig. 8).

Right valve somewhat irregular in shape, mostly subcircular, rather flat, but always with a distinct convexity of the umbonal region. Anterior ear very short and acute, posterior ear short and less acute; ribbing much weaker than on left valve, usually rather faint with no clear separation of primary and secondary ribs; also, distance between ribs greater than on left valve; concentric growth-rings mostly clearly visible, do not cross the ribs. Hinge (fig. 3) similar to that of *Echinotis echinata* (see Pompeckj 1901, Marwick 1936); ligament pit slightly longer than in that species. Muscle scar slightly smaller than in right valve.

Occurrence: In strata of Bajocian age with *Ostrea tholiformis, Trigonia moorei, Dorsetensia clarkei* and a rich fauna of other species in railway cutting on Geraldton-Mullewa line, nineteen and a half miles east of Geraldton, near Newmarracarra, and in strata with *Parachaetetes megalocytus* and *Ostrea tholiformis* in the locality described in the preceding section, viz., 30 chains (600 metres) southeast of Curdamuda Well, Minilya River, Wandagee Station, North-West Basin. The holotype has been selected from among the better preserved material from the first-named locality.

Remarks: Specimens very probably belonging to this species were first mentioned by Moore in 1870 (pp. 230, 232) who listed them as *Avicula echinata,* but apparently the species was not represented in the collection of Jurassic fossils studied by Etheridge (1910). It was again discussed by Whitehouse in 1926 who, however, only had one specimen at his disposal which he provisionally referred to *Pseudomonotis echinata.* Whitehouse had studied a large suite of individuals of this latter species from the Cornbrash of England and pointed out that the Western Australian specimen was "somewhat more circular in outline and has more pronounced division of the ribs into primaries and secondaries than the *average* English form; but the variation of the species in the Callovian covers such forms as the present."

The collections of the Department of Geology of the University of Western Australia contain a quantity of specimens which are evidently conspecific with the specimen studied by Whitehouse and, although I have not seen many specimens of the European *Echinotis echinata,* a careful comparison of published figures and descriptions of that species shows that the Australian form is not sufficiently similar to *Echinotis echinata* to be included in that species. Among the older descriptions of *Echinotis echinata* those by Sowerby (1821) and by Morris and Lycett (1853) are important. More recently, the species has been discussed and figured by Douglas and Arkell (1933), by Stoll (1934) and by Marwick (1936).

The following differences can be found between *Echinotis echinata* and *E. sinuata*:—

(1) *sinuata* attains a larger size than *echinata;*

(2) the ribs of *sinuata* are generally smooth, individuals with knotted ribs, like those of *echinata,* are very rare

(3) in *sinuata* separation of ribs into primaries and secondaries is the rule;

(4) posterior swelling and shallow sinus, characteristic of adult specimens of *sinuata*, are absent in *echinata*.

Since the range of variation of *Echinotis sinuata* is very considerable, certain specimens are more similar to *E. echinata* than the majority of average specimens.

The specimens from the Minilya River show less tendency towards the development of secondary ribs than the specimens from the Geraldton district. Also, though the few full-grown specimens obtained from the Minilya River are poorly preserved, they seem, as a rule to have a shallower posterior sinus than the Geraldton specimens.

Echinotis sinuata differs from the otherwise very similar *E. decussata* in the smaller number of ribs.

It may be noted that *E. sinuata* is not similar to the New Zealand form described by Trechmann (1923) as *Pseudomonotis* cf. *echinata*. As was also observed by Marwick (1936) that form is remarkably close to the typical European *Echinotis echinata*.

Genus **OSTREA** Linné.

Ostrea tholiformis Etheridge.

1910—*Ostrea tholiformis*, Etheridge, Oolit. Foss., p. 30, pl. 7, figs. 2-7.

This species has been well described by Etheridge from specimens from various localities in the Geraldton district. The specimen figured by Etheridge on pl. 7, fig. 3, now in the collection of the Geological Survey of Western Australia, is here selected as holotype.

The species is well represented in the collections from the railway cutting nineteen and a half miles east of Geraldton from which *Echinotis sinuata* has been described above. In the algal beds on the Minilya River, Wandagee Station, fragments of *Ostrea* shells are rather numerous, but only one almost complete specimen of an upper flat valve has been found which agrees well with specimens from the Geraldton district. Nothing can be added to Etheridge's description of the species.

ACKNOWLEDGMENTS.

The writer was accompanied in the field by Messrs. H. G. Higgins and E. P. Utting who supplied some of the data on which the map fig. 2 is based. Mr. G. Gordon Gooch very kindly provided numerous facilities, while the work on Wandagee Station was in progress, and Mr. Henry Coley first called the writer's attention to the occurrence of fossils in the locality described in this paper. Professor E. de C. Clarke kindly read and criticized the manuscript. The writer wishes to express his sincere appreciation of these services. Figs. 2, 3 and 4 and the accompanying plate were prepared by Mrs. Gertrude Teichert.

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EXPLANATION OF PLATE I.

Echinotis sinuata sp. nov. Figs. 1-8: Specimens from railway cutting nineteen and a half miles east of Geraldton; Figs. 9 and 10: Specimens from 20 chains south-east of Curdamuda Well, Minilya River, Wandagee Station, Carnarvon District.

Figs. 1-3.—Left, right and anterior views of holotype. No. 19211. The posterior ear is damaged.

Fig. 4.—Internal view of left valve of another specimen, showing posterior ear. No. 19213.

Fig. 5.—External view of left valve of another specimen, showing knotted appearance of ribs. No. 19214.

Figs. 6, 7.—External and internal views of right valve of another specimen, showing stronger development of secondary ribs than holotype. No. 19216.

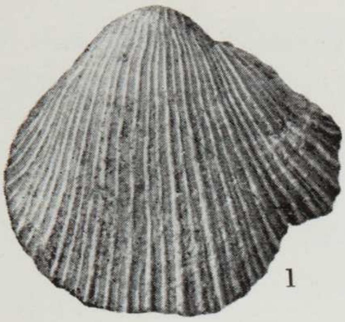
Fig. 8.—Largest specimen in collection. No. 19217. Posterior ear damaged.

Fig. 9.—Left valve, showing well developed primary and secondary ribs. No. 19218.

Fig. 10.—Portion of larger left valve; secondary ribs weakly developed, posterior ear large. No. 19219.

All figures enlarged 1½ diameters. Specimens in the Department of Geology of the University of Western Australia.

PLATE I.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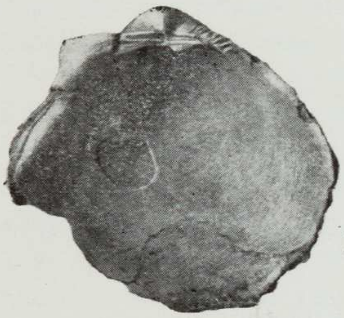
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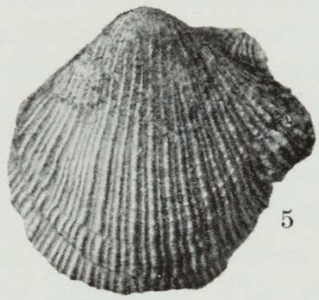
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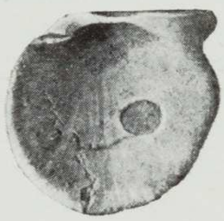
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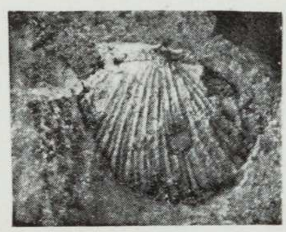
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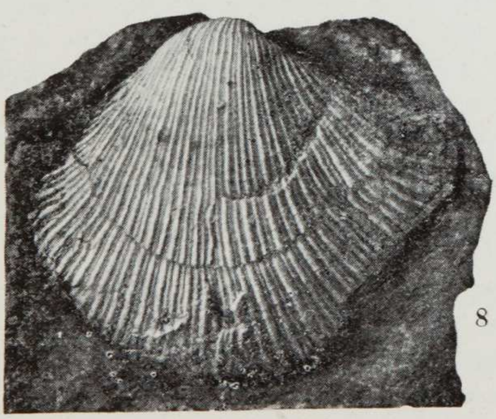
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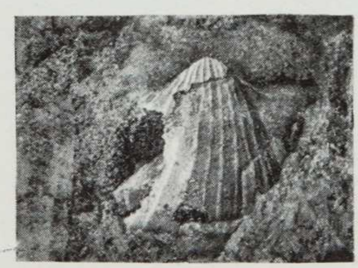
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